FEATURES OF DESIGN AND NUMERICAL MODELING OF FLOW STABILIZERS IN SYSTEMS FOR SYNCHRONIZING THE MOVEMENT OF EXECUTIVE BODIES

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https://doi.org/10.5281/zenodo.10088345

Abstract. When solving problems of synchronizing the movement of executive bodies of technical systems, hydraulic methods are used, which are based on the use of flow stabilizers that maintain a constant speed of movement of the executive bodies when exposed to various dynamic loads. Issues related to the design, design features and numerical modeling of the flow stabilizer are considered, ensuring a given value of the volumetric flow rate of the working fluid in a wide range of pressure drops, which is determined by the spread of loads on the executive bodies. The results of computer modeling of physical processes in the flow stabilizer, formation of the appearance of the FS, methodology for determining static characteristics are studied.
Keywords: flow stabilizers, working fluid, hydrodynamic force, Synchronization.

Introduction. In industrial installations, including on aircraft, hydraulic synchronization systems for the movement of executive bodies (EB) are widely used, which are exposed to alternating loads of varying magnitude. Synchronization or preservation by a group of IEs of movement speed within specified limits under different loads is achieved by using regulators - flow stabilizers (FS) of the working fluid (WF), operating in a wide range of pressure drops, determined by the spread of loads on the EB [1–6]. The stability of the flow rate depends on the design of the FS flow part and on the unbalanced hydrodynamic force created by the WF jet flowing through the regulating spool pair "SR window–spool edge" [4, 7–9]. It is known that the hydrodynamic force depends on the pressure drop across the control spool pair, affects the movement of the spool, and is the main reason for the occurrence of static in the flow-difference (static) characteristic and, consequently, an increase in the mismatch in the speed of movement of the EB for the systems under consideration. Determining the hydrodynamic force by calculation at the early stages of design is associated with difficulties in mathematical modeling of the flow process of the liquid fluid in the internal cavity of the FS [10, 11]. The corresponding analytical dependencies were obtained only for specific design options of control spool pairs and are not applicable to other options. Therefore, to determine the hydrodynamic force, it is customary to use the results of hydraulic tests, according to which it is necessary to verify mathematical models of the FS. This article discusses the features of designing a FS for EB synchronization systems: the formation of the appearance of the FS, numerical modeling of its working processes, experimental determination of static characteristics and hydrodynamic force, design solutions for unloading the spool from the influence of unbalanced forces.

Formation of the appearance of the FS. An experimental FS was used as the object of study, the design diagram of which is shown in Fig. 1 [12].

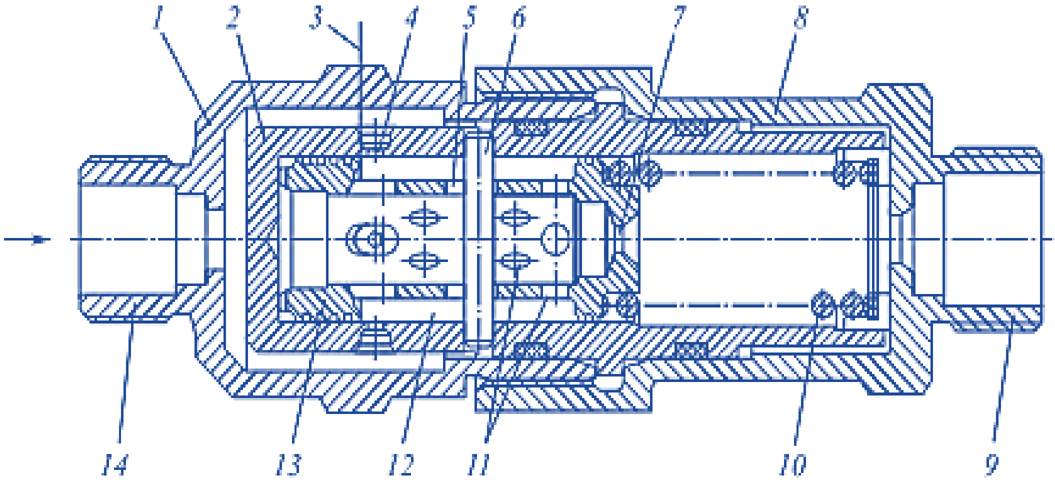

Fig 1. FS design diagram: 1 - split housing (part 1); 2 - sleeve; 3 — sharp edge of the spool; 4 - windows; 5 - grooves; 6 - rod; 7 - calibrated throttle; 8 — split housing (part 2); 9 — outlet fitting; 10 - spring; 11 — round holes; 12 — ring channel; 13 — spool; 14 -inlet fitting

The WF flow stabilizer works as follows. The device has two sequential throttling sections, of which the first section (calibrated 7) is unregulated. The spool pair, windows 4 of the sleeve 2 and the sharp edge 3 of the spool 13, is the second throttling section that regulates the flow rate of the WF depending on the pressure drop across the FS. In the absence of hydrodynamic force and friction force (ideal FS), the principle of operation of the FS is determined by the ratio of the force created by the pressure drop across the calibrated throttle 7 and the force on the spool 13 created by the spring 10. If the pressure drop across the FS increases, then the flow rate of the liquid through it deviates from setting value (flow increases), and, consequently, the pressure drops across the calibrated throttle 7 and spool 13 increase. As a result, the spool 13 moves, compressing the spring 10 and blocking the window 4 with a sharp edge 3, reducing their flow area, while the flow rate of the coolant is reduced to setting value. When the pressure drop decreases, the FS restores the set value of the WF flow rate in accordance with the principle of operation given earlier.

Methodology for determining static characteristics. The functioning of the FS as part of the synchronization system for the movement of the EB occurs under conditions of dynamic (impact) influence on it from the WF. The hydrodynamic force acting on the spool and causing static flow characteristics occurs when flowing around its surface during the high-speed movement of the fluid in the internal cavities of the FS. To take into account the influence of these factors, the static characteristics of the FS are formed based on the results of measuring its dynamic parameters (pressure drop and volumetric flow rate of the WF) and the results of computational experiments. Taking into account the wide range of changes in pressure drops across the FS and the need to ensure the specified accuracy of their determination, during dynamic tests this range was divided into separate sections, for which pressure sensors with such measurement limits were selected that would ensure the required accuracy of the measured parameter.

Conclusion

The design features of the FS as an element of the system for synchronizing the movement of executive bodies, which maintain the value of the main parameter in the extended range of pressure drop, are shown. The method of determining static properties through dynamic parameters was studied. The study shows that it allowed to minimize the axial component and compensate the radial component of the hydrodynamic force, as well as obtain an empirical analytical expression for the coefficient of the axial component of the hydrodynamic force.

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